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**(54) Electrical signal line cable assembly**

Kabelzusammenbau für elektrische Signalleitungen

Assemblage de câble pour lignes de signaux électriques

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(56) References cited:  
**US-A- 4 847 443** **US-A- 5 552 565**

**EP 0 903 757 B1**

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**Description**

[0001] Electrical signal lines are known, for example, from European Patent Application EP-A-0 735 544 (Cartier et al.) assigned to Hewlett-Packard Company. This patent application describes an ultrasound system with a transducer cable for providing an electrical connection between a transducer and a display processor. The third embodiment of the transducer cable in this application uses three layers of extruded ribbon assemblies separated from each other by shield conductors comprising thin strips of bare copper. The stack of ribbon assemblies and shield conductors are extruded with a ribbon jacket to form a desired length of the transducer cable.

[0002] US-A-4 847 443 (Basconi) assigned to the Amphenol Corporation teaches another example of an electrical signal line cable formed from a plurality of generally flat electrical signal line segments stacked together in an interlocking relationship. Each electrical signal line segment of this prior art cable contains at least one signal conductor surrounded on either side by ground conductors. The plurality of ground conductors effectively form a ground plane which inhibit the cross-talk between the adjacent signal conductors. The insulating materials in which the conductors are disposed is extruded over the individual signal conductors.

[0003] European Patent EP-B-0 605 600 (Springer et al.) assigned to the Minnesota Mining and Manufacturing Company teaches a ribbon cable and a lamination method for manufacturing the same. The ribbon cable manufactured comprises a plurality of evenly spaced flexible conductors surrounded by an insulator which is a microporous polypropylene.

[0004] US Patent US-A-4 972 041 (Crawley et al.) assigned to W.L.Gore & Associates teaches a multi-conductor flat ribbon cable having a plurality of electrical conductors disposed within an insulator consisting of expanded polytetrafluoroethylene (ePTFE).

[0005] PCT patent application WO-A-91/09406 (Ritchie et al) teaches an electrical wiring composed of elongated electrically conductive metal foil strips laminated between opposing layers of insulating films by means of adhesive securing the foil strips between the laminating films.

[0006] German patent application DE-A-24 24 442 assigned to Siemens teaches a cable assembly which comprises a plurality of flat cables laminated between insulating films.

[0007] PCT patent application WO-A-80/00369 (Clarke) assigned to Square D company of Palatine, Illinois, teaches an input/output data cable for use with programmable controllers. The cable has a ground conductor, a logic level voltage conductor and a number of signal tracks. The conductors are disposed on two or three flayers of flexible plastics material in specified ways to give high immunity to interference and low inductive losses. The layers are glued together to form a laminate structure.

[0008] W.L.Gore & Associates, Inc., in Phoenix, Arizona, sell a round cable under the part number 02-07605 which comprises 132 miniature co-axial cables enclosed within a braided shield of tin-plated copper and a jacket tube of PVC.

[0009] There remains a need in the art to develop an electrical signal cable assembly having a plurality of ribbon cables which is light in weight and offers coaxial performance characteristics.

**Summary of the Invention**

[0010] It is therefore the object of this invention to develop a signal cable assembly having a plurality of ribbon cables in which the cross talk between the individual signal conductors is minimised.

[0011] Furthermore the invention provides a signal cable assembly having a plurality of ribbon cables that is light in weight compared to a comparable assembly of miniature coaxial cables.

[0012] The invention also provides a signal cable assembly with a plurality of ribbon cables which is light in weight compared to a comparable assembly of miniature coaxial cables.

[0013] These and other objects of the invention are achieved by providing an electrical signal cable assembly with at least one ribbon cable arranged in at least one first concentric array around a cylindrical spacer and a separating concentric shielding strip disposed about the first concentric array. At least one further ribbon cable is arranged in at least one further concentric array about the separating concentric shielding strip.

[0014] The use of a separating concentric shielding strip between the first and further concentric arrays shields the electrical conductors between the ribbon cables such that cross talk between signals carried in the electrical conductors is minimised. The use of concentrically disposed ribbon cables provides a flexible signal cable assembly and also one in which the electrical conductors are held in place and therefore can be individually and easily identified.

[0015] In a preferred embodiment of the invention at least one of the plurality of electrical conductors in the ribbon array is connectable to ground potential and at least a further one of the plurality of electrical conductors is connectable to a signal. The use of an electrical conductor connected to ground potential between electrical conductors connected to signals provides additional shielding between the signal conductors.

[0016] Preferably an outer shield is disposed about the further concentric array to provide additional shielding from external stray electromagnetic fields. Furthermore a jacket is disposed about an outside of said electrical signal cable

assembly to protect the complete signal cable assembly from mechanical damage.

[0017] A further embodiment of the invention provides for a third concentric array disposed about the further concentric array and separated from the further concentric array by a further concentric separating shielding strip. This provides additional signal conductors that are shielded from the signal conductors in the first and further concentric arrays.

[0018] The ribbon cable is preferably formed electrical conductors sandwiched between insulators made from the group of insulating materials consisting of perfluoralkoxy, fluoroethylene-propylene, polyester, polyolefin including polyethylene and polypropylene, polymethylpentene, full density polytetrafluoroethylene or expanded polytetrafluoroethylene. Most preferably expanded polytetrafluoroethylene is used which has a very low dielectric constant and is light in weight.

#### Description of the Drawings

##### [0019]

Fig. 1 shows the electrical signal line cable assembly according to a first embodiment of the invention.  
 Fig. 2 shows a method for the manufacture of an electrical signal line cable assembly of the invention.  
 Fig. 3 shows the electrical signal line cable according to a second embodiment of the invention.  
 Fig. 4 shows the electrical signal line cable according to a third embodiment of the invention.  
 Fig. 5 shows a device for the manufacture of the subcable assemblies in the electrical signal line cable.  
 Fig. 6 shows a sintering device used in the manufacture of the subcable assemblies.  
 Fig. 7 shows a further example of a subcable assembly suitable for use in the invention.  
 Fig. 8 shows a fourth embodiment of the invention.

#### Detailed Description of the Invention

[0020] Fig. 1 shows a first embodiment of the invention. It shows an electrical signal line 10 comprising a plurality of subcable assemblies 20. In Fig. 1 eight sub cable assemblies 20 are shown. However, this is merely illustrative of the invention and not intended to be limiting.

[0021] Each subcable assembly 20 comprises a plurality of individual signal conductors 30 arranged in a parallel plane and surrounded by an upper insulating layer 40a and a lower insulating layer 40b. The upper insulating layer 40a and the lower insulating layer 40b are laminated together as will be explained later. The individual signal conductors 30 can be made from any conducting material such as copper, nickel-plated copper, tin-plated copper, silver-plated copper, tin-plated alloys, silver-plated alloys or copper alloys. Preferably the individual signal conductors are made of round copper wire. It would also be possible to use flat conductors.

[0022] The number of individual signal conductors 30 depicted in Fig. 1 is not intended to limiting of the invention. The axes of the individual signal conductors 30 are separated by a first pitch distance  $a$  which is in the range of 0,1 to 1 mm. The upper insulating layer 40a and the lower insulating layer 40b can be made of any insulating dielectric material such as polyethylene, polyester, perfluoralkoxy, fluoroethylene-propylene, polypropylene, polymethylpentene, polytetrafluoroethylene or expanded polytetrafluoroethylene. Preferably expanded polytetrafluoroethylene such as that described in US-A-3 953 556, US-A-4 187 390 or US-A-4 443 657 is used.

[0023] The subcable assemblies 20 are separated from each other by a shielding strip 50. The shielding strip 50 is made for example from a metal foil, metal braid, conductive tape or a metallised textile. The following metals can be used: copper, tin, silver, aluminium or alloys thereof. In one embodiment of the invention the shielding strip 50 was made from copper-coated polyamide fabric of the Kassel type supplied by the Statex company in Hamburg, Germany, and had a thickness of approximately 0,1 mm and a width of around 9 mm.

[0024] The subcable assemblies 20 were arranged in a planar manner, one above another, to form a bundle of subcable assemblies 20 using the apparatus 100 shown diagrammatically in Fig. 2.

[0025] Fig. 2 shows a plurality of first spools 102 onto which is rolled a first strip 103 forming the subcable assembly 20 and a plurality of second spools 104 onto which is rolled a second strip 105 forming the shielding strip 50. A plurality of first (subcable assembly) strips 103, separated from each other by a second (shielding) strip 105 is rolled respectively off the plurality of first spools 102 and the plurality of second spools 104 and joined together at position 106 to form a bundle 107.

[0026] The thus created bundle 107 of subcable assemblies 20 was slid into a tube which forms a first shielding means 60. The first shielding means 60 may be made of a metal foil, such as a foil made from copper, aluminium or silver, or from metallised textile. In one embodiment of the invention the first shielding means was made from Kassel copper-coated polyamide fabric supplied by the Statex company in Hamburg, Germany, and had a thickness of fabric supplied by the Statex company in Hamburg, Germany, and had a thickness of approximately 0,1 mm and a width of

around 9 mm. Crescent-shaped Spacers 90 were positioned between the plurality of subcable assemblies 20 and the first shielding means 60 in order to maintain a substantially tubular shape. The spacers 90 are made from permeable ePTFE, PTFE, polyamide, perslon or any other dielectric material.

**[0027]** Shielding strip ends 55 project beyond an edge 25 of the subcable assemblies 20 and are bent downwardly or upwardly such that each shielding strip end 55 touches another one of the shielding strip ends 55. At least one of the shielding strip ends 55 is in electrical contact with the first shielding means 60. In Fig. 1, the shielding strip ends 55 of the outermost ones of the plurality of subcable assemblies 20 and the subcable assemblies 20 immediately adjacent to the outermost ones of the subcable assemblies 20 is shown as being in electrical contact with the first shielding means 60. Each of the shielding strips 50 and the first shielding means 60 are therefore held at the same potential. It would, of course, be possible to hold the shielding strips 50 and the first shielding means 60 at a different potential. In this latter case the shielding strip ends 55 would not electrically contact with the shielding means 60.

**[0028]** An insulating layer 65 was then wrapped around the first shielding means 60 using known wire wrapping techniques. The insulating layer 65 may be made, for example, from PTFE, FEP, ePTFE or polyester. Preferably the insulating layer 65 is made from sintered GORE-TEX® tape which is obtainable from W.L.Gore & Associates.

**[0029]** A second shielding means 70 surrounds the first shielding means 60. The second shielded means 70 is a braid, foil or wire shield made from a metal or a metallised polymer, such as copper, aluminium, tin-plated copper, silver-plated copper, nickel-plated copper or aluminised polyester. In one embodiment of the invention the second shielding means 70 is made from a copper braid with a braiding angle of about 35°.

**[0030]** A jacket 80 is placed over the second shielding means 70. The jacket 80 is made from silicone or polyolefins such as polyethylene, polypropylene or polyethylpentene; fluorinated polyurethane, polyvinylchloride (PVC) or polytetrafluoroethylene (PTFE) or expanded PTFE. In one embodiment of the invention the jacket 80 was made from PVC.

**[0031]** A second embodiment of the invention is shown in Fig. 3. In this figure, the same reference numerals are used to denote components of the electrical signal line 110 having the same function as the components of the electrical signal line 10 of Fig. 1 except that the numerals are increased by 100. In this embodiment of the invention a tubular spacer 190 is used in the core of the electrical signal line 110 and the subcable assemblies 120 are wrapped in a helical manner with an axis through the core 200 of the electrical signal line 110. The materials used for the construction of this embodiment of the electrical signal line 110 are the same as those used above.

**[0032]** The second embodiment of the electrical signal line 110 has the advantage that it is substantially more flexible than the first embodiment.

**[0033]** A third embodiment of the electrical signal line is shown in Fig. 4. Again the same reference numerals are used to denote components of the electrical signal line 210 having the same function as the components of the electrical signal line 10 of Fig. 1 or the electrical signal line 110 of Fig. 2 except that the numerals are increased by a further 100. In this embodiment of the electrical signal line, the plurality of subcable assemblies 220 are twisted before being placed within the first shielding means 260 thus obtaining a substantially more flexible electrical signal line 210. Again the same materials are used for the construction of this electrical signal line 210 as are described in the first embodiment of the invention.

**[0034]** Manufacture of the subcable assemblies 20, 120 and 220 is illustrated in Fig. 5 for the embodiment in which the upper insulating layer 40a and the lower insulating layer 40b are made from expanded PTFE. This method is essentially the same as that taught in US-A-3082292 (Gore). The same reference numerals are used to denote the components of the subcable assembly 20, 120 and 220 as those used for the components of the subcable assembly 20 in the first embodiment of the invention (Fig. 1) except that they are increased by 300. A plurality of individual signal conductors 330, an upper insulator 340a located above assembly 20 in the first embodiment of the invention (Fig. 1) except that they are increased by 300. A plurality of individual signal conductors 330, an upper insulator 340a located above the plurality of individual signal conductors 330, and a lower insulator 340b located below the plurality of individual signal conductors 340b were communally passed between two contra-rotating pressure rollers 400a and 400b at a lamination temperature sufficient to achieve bonding between the lower insulator 340b and the upper insulator 340a, e.g. between 327°C and 410 °C. A subcable assembly 320 was thereby formed. For this purpose, the upper pressure rollers 400a is provided with a number of upper peripheral grooves 410a each separated by an upper peripheral rib 420a which are lined up at a distance from one another along the circumference of the pressure rollers 400a. Similarly, the lower pressure rollers 400b is provided with a number of lower peripheral grooves 410b each separated by a lower peripheral rib 420a which are lined up at a distance from one another along the circumference of the pressure roller 400b. Each upper peripheral groove 410a of the upper pressure roller 400a together with the adjacent upper peripheral ribs 420a lines up with one of the lower peripheral grooves 410b with the adjacent lower peripheral ribs 420b of the lower pressure roller 400b to form a passageway channel for one of the individual signal conductors 330. The distance between the two pressure rollers 400a, 400b and the peripheral grooves 410a, 410b are designed in terms of their dimensions in such a way that a single conductor 330 and the upper insulator 340a and the lower insulator 340b pass continuously between a pair consisting of one of the upper peripheral grooves 420a and one of the lower peripheral grooves 420b. The upper peripheral ribs 420a and the lower peripheral ribs 420b have such a small separation from

one other that the upper insulator 340a and the lower insulator 340b are firmly pressed together at these positions to form an intermediate zone 440 in the subcable assembly 320.

[0035] In order to improve their adhesion of the upper insulator 340a to the lower insulator 340b to the individual signal conductors 330 and with each other within the subcable assembly 320, the subcable assembly was led through a sintering device in which the subcable assembly 320 is heated such that one achieves intimate joining in the intermediate zones 440 of the subcable assembly 320. If using an upper insulator 340a and a lower insulator 340b made of PTFE, use is made of a sintering temperature in the range from 327° to 410°C.

[0036] An example of an embodiment of a sintering device in the form of a sintering oven 450 comprising a salt bath is illustrated in a schematic and simplified form in Figure 6. In this example, the subcable assembly 320 is continually passed through the sintering oven 450.

[0037] Fig. 7 shows a further example of a subcable assembly 620 which comprises a plurality of individual signal electrical signal conductors 630 arranged in a parallel plane and surrounded by an upper insulating layer 640a and a lower insulating layer 640b. The subcable assembly 620 further included an upper shielding means 650a and a lower shielding means 650b attached to the outer surfaces of the upper insulating layer 640a and the lower insulating layer 640b respectively. The upper shielding means 650a and the lower shielding means 650b can be made, for example, from copper or aluminium foil, perforated copper foil or metallised polyamide. In the preferred embodiment they are made from copper foil. The upper shielding means 650a and the lower shielding means 650b are joined to each other at ends 660a and 660b as shown in Fig. 7. A jacket 680 made from ePTFE was attached to the upper shielding means 650a and the lower shielding means 650b. The jacket 680 could also be made from PFA, FEP or PTFE.

[0038] Manufacture of the embodiment of the subcable assembly 620 depicted in Fig. 7 is carried out in a similar manner as the subcable assembly 320 described above and depicted in Fig. 5. In addition to the upper insulator 340a and the lower insulator 340b being passed through the contra-rotating pressure roller 400a and 400b at a lamination temperature, the material to form the upper shielding means 650a, the lower shielding means 650b and the jacket 680 are additionally passed through contra-rotating pressure rollers at a temperature sufficient to ensure that the upper shielding means 650a and the lower shielding means 650b are laminated to the upper insulating 640a and the lower insulator 640b and to each other at the ends 660a, 660b.

[0039] Use of the laminated upper shielding means 650a and the lower shielding means 650b allows the construction of an electrical signal line 10 with a plurality of subcable assemblies 620 without a shielding strip 50 placed between the subcable assemblies 620.

### Examples

#### Example A

[0040] The construction of this example is depicted in Fig. 8 in which the same reference numerals are used to denote the same feature as those in Fig. 1 except that the numerals are increased by 700. The individual signal conductors 730 were made from AWG 4001 copper wire and embedded within an upper insulating layer 740a and a lower insulating layer 740b of GORE-TEX® tapes made in the Pleinfeld, Germany, plant of W.L. Gore & Associates. Each subcable assembly 720 contained sixteen of the individual signal conductors 730. The pitch distance a between the individual signal conductors was 0.35 mm. Four subcable assemblies 720 were bundled together on top of each other with no shielding strip 750 between them to form a subcable assembly bundle 725. A pair of subcable assembly bundles 725 were then placed together with a shielding strip 750 made of Kassel copper-coated polyamide fabric supplied by the Statex company. The pair of subcable assemblies bundles 725 were slipped inside a tube forming the first shielding means 760 and made of Kassel copper-coated polyamide fabric. One of a shielding strip end 755 was placed in electrical contact with the first shielding means 765. An insulating layer 765 of GORE-TEX® insulating tape was subsequently wrapped around the first shielding means 760. The second shielding means 770 was made of tin-coated copper braid and a jacket 780 made from polyvinyl chloride was then slipped over the insulating layer 765. An electrical signal line cable assembly 710 containing eight subcable assemblies 720 and 128 individual signal conductors 730 was thus obtained.

#### Example B

[0041] This example was constructed according to the first embodiment of the invention and is depicted in Fig. 1. The individual signal conductors 30 were made from AWG 4001 tin-plated copper wire and embedded within an upper insulating layer 40a and a lower insulating layer 40b of GORE-TEX® tapes made in the Pleinfeld, Germany, plant of W.L. Gore & Associates. Each subcable assembly 20 contained sixteen of the individual signal conductors 30. The pitch distance a between the individual signal conductors was 0.35 mm. Eight subcable assemblies 20 were bundled together on top of each other with a shielding strip 50 strip made of Kassel copper-coated polyamide fabric supplied

## EP 0 903 757 B1

by the Statex company between each of the subcable assemblies 20. The shielding strip ends 55 were placed in electrical contact with the first shielding means 65. The eight subcable assemblies 20 were slipped inside a tube made of Kassel copper-coated polyamide fabric forming the first shielding means 60 and an insulating layer 65 of GORE-TEX® insulating tape was wrapped around the Kassel fabric. The second shielding means 70 was made of tin-plated copper braid and a jacket 80 made from polyvinyl chloride was then slipped over the insulating layer. An electrical signal line cable assembly 10 containing 8 layers and 128 individual signal conductors was thus obtained.

### Example C

[0042] This was manufactured in the same manner and using the same materials as example B except that AWG 4207 copper wire was used.

### Comparative Example

[0043] As a comparison a conventional flat cable comprising a bundle of 132 miniature co-axial cables was used. The conductors were made of AWG 4207 silver-plated alloy wire, the insulator of ePTFE and the outer conductor of silver-plated copper. A jacket of a fluoropolymer was extruded over the outer conductor. A braided shield of tin-plated copper was then slid over the bundle of 132 miniature co-axial cables and a jacket tube of PVC was slid over the braided shield. This electrical signal line assembly is commercially available from W.L.Gore & Associates under the part number 02-07605

Table 1 shows a comparison of the electrical and mechanical properties of the electrical signal line manufactured according to this invention in comparison to the cables of the comparative example, an electrical signal line available from W.L.Gore & Associates.

Electrical Properties				
Impedance	~ 100 $\Omega$	~ 75 $\Omega$	~ 100 $\Omega$	78 $\Omega$
Capacitance	~ 48 pF/m	~ 57 pF/m	~ 48 pF/m	52 pF
Attenuation @ 5 MHz	1,20 dB/Assy.	0,73 dB/Assy.	0,7 dB/Assy.	1,09 dB/Assy.
Attenuation @ 10 MHz	1,67 dB/Assy.	0,89 dB/Assy.		1,17 dB/Assy.
Velocity of Signal Propagation compared to velocity of light.	81,1 %	81,0 %	81,0 %	76,6 %
X-talk: Signal/Signal	17,4 dB	20,3 dB		36 dB
Subcable1/subcable2	30,1 dB	35,4 dB	36 dB	
Subcable1/subcable3	39,4 dB	42,3 dB		
Subcable1/subcable4	47,6 dB	44,4 dB		
Bundle/Bundle (sc4sc3)	50,5 dB			
Mechanical Properties				
Weight	225 g	237 g		ca. 300 g
Length	2,5 m	2,5 m		2,5 m

[0044] For Examples A and B five values are given for the cross-talk. The signal/signal value is the cross-talk between

any two adjacent electrical signal conductors 30 in the same subcable assembly 20. For example A, the value for subcable1/subcable2 is the cross talk between two corresponding electrical signal conductors 730 in two adjacent subcable assemblies 720 in the same subcable assembly bundle 725, i.e. with no shielding strip 750 between the two adjacent subcable assemblies 720. The value for subcable1/subcable3 is the cross talk between two corresponding electrical signal conductors 730 in two subcable assemblies 720 separated by one subcable assembly 730 in the same subcable assembly bundle 725. Similarly, the value for subcable1/subcable4 is the cross talk between two corresponding electrical signal conductors 730 in two subcable assemblies 720 separated by two subcable assemblies 720 in the same subcable assembly bundle 725, i.e. the first and last subcable assemblies 720 in one of the subcable assembly bundles 725. The value for the bundle/bundle crosstalk of example A is obtained by measuring the cross talk between two corresponding electrical signal conductors 730 in the subcable assemblies 720 immediately adjacent to the shielding strip 750, i.e. the first subcable assembly 720 in one of the subcable assembly bundles 725 and the last subcable assembly 720 in the other of the subcable assembly bundles 725.

**[0045]** The cross talk values for examples B and C are measured in the same manner except, of course, that there is always at least one shielding strip 50 between the two electrical signal conductors 30 in the different subcable assemblies 20. There is no value given for the bundle/bundle cross talk since the subcable assemblies 20 of examples B and C are not bundled.

**[0046]** The value for the cross talk given for the comparative example is the value measured between any two adjacent electrical signal conductors.

**[0047]** It can be seen from this table that the electrical signal lines manufactured according to this invention have a much better velocity of signal propagation compared to the comparative example. By suitable choice of electrical signal conductors the cross-talk can be reduced to a value which is at least comparable to that in the comparative example. Indeed in practice it is known that any value greater than 20 dB is acceptable. For the same length of line, the inventive electrical signal lines are substantially lighter, i.e. for 132 lines a weight saving of up to 25% is achievable.

#### Examples D-M

**[0048]** Table 2 shows the results of further examples of the invention which are constructed according to the embodiment depicted in Fig. 1.

Table 2

Example	D	E	F	G	H	I	J	K	L	M
Signal Conductor (AWG)	4607	4607	3807	3807	2807	2807	2807	2807	2807	2807
Dielectric	ePTFE	ePTFE	ePTFE	ePTFE	ePTFE	ePTFE	ePTFE	FEP	FEP	FEP
Characteristic Impedance ( $\Omega$ )	50	80	50	80	50	80	200	50	80	200
Dist. between conductors (mm)	0.09	0.18	0.21	0.44	0.77	2.24	15.85	1.04	3.85	44.7
Capacitance (pF/m)	76	47	76	47	76	38	19	96	48	24

[0049] As signal conductors, copper wire is used. AWG 4607 copper wire has an outer diameter of 0.048 mm. AWG

3807 has an outer diameter of 0.12 mm. AWG 2807 has an outer diameter of 0.381 mm. ePTFE dielectric has a dielectric constant of 1.3 and FEP has a dielectric constant of 2.1.

[0050] It will be seen from table 2, that by a suitable choice of dielectric, distance between conductors and signal conductor, it is possible to construct electrical signal cable assemblies with characteristic impedances between 50  $\Omega$  and 200  $\Omega$ .

#### Examples N-P

[0051] Table 3 shows further examples constructed according to the embodiment shown in Fig. 1 but using different dielectric materials.

Table 3

Example	N	O	P
Signal Conductor (AWG)	4007	4007	4007
Dielectric	PFA	PE	PES
Characteristic Impedance ( $\Omega$ )	50	50	50
Dist. between conductors (mm)	0.22	0.24	0.32
Capacitance (pF/m)	96	101	120

[0052] In examples N-P AWG 4007 copper wire is used with an outer diameter of 0.09 mm. The dielectric material PFA has a dielectric constant of 2.1, polyethylene (PE) has a dielectric constant of 2.3 and polyester (PES) has a dielectric constant of 3.3.

[0053] Although a few exemplary embodiments of the present invention have been described in detail above, those skilled in the art readily appreciate that many modifications are possible without materially departing from the novel teachings and advantages which are described herein.

[0054] Accordingly, all such modifications are intended to be included within the scope of the present invention, as defined by the following claims.

#### Claims

##### 1. Electrical signal cable assembly comprising (110)

- at least one ribbon cable (120) arranged in at least one first concentric array around a cylindrical spacer,
- a separating concentric shielding strip (150) disposed about the first concentric array (120), and
- at least one further ribbon cable (120) arranged in at least one further concentric array about the separating concentric shielding strip (150).

##### 2. Electrical signal cable assembly (110) according to claim 1 wherein the at least one ribbon cable (120) comprises a plurality of electrical conductors (130) and

- at least one of the plurality of electrical conductors (30) is connectable to AC ground potential, and
- at least a further one of the plurality of electrical conductors (30) is connectable to a signal.

##### 3. Electrical signal cable assembly (110) according to any of the above claims wherein said ribbon cables (120) are served about the cylindrical spacer (190).

##### 4. Electrical signal cable assembly (110) according to any of the above claims wherein an outer shield (170) is disposed about the further concentric array (120).

##### 5. Electrical signal cable assembly (110) according to claim 4 wherein an outer binder (165) is disposed between the further concentric array (120) and the outer shield (170).

6. Electrical signal cable assembly (110) according to any of the above claims wherein a jacket (180) is disposed about an outside of said electrical signal cable assembly (110).
- 5 7. Electrical signal cable assembly (110) according to any of the above claims further including at least one ribbon cable (120) disposed in at least a third concentric array (120) about the further concentric array (120) and separated from the further concentric array (120) by a further concentric separating shielding strip (150).
8. Electrical signal cable assembly (110) according to any of the above claims wherein the at least one ribbon cable (120) comprises an upper insulator (40a) attached to a lower insulator (40b) with a plurality of electrical conductors (130) disposed therein.
- 10 9. Electrical signal cable assembly according to claim 8 wherein said ribbon cable insulator (40a, 40b) comprises an upper insulator sintered (40a) to a lower insulator (40b).
- 15 10. Electrical signal cable assembly according to any of the above claims wherein the insulator (40a, 40b) of the at least one ribbon cable (120) is formed from the group of insulating materials consisting of perfluoralkoxy, fluoroethylene-propylene, polyester, polyolefin including polyethylene and polypropylene, polymethylpentene, full density polytetrafluoroethylene or expanded polytetrafluoroethylene.
- 20 11. Electrical signal cable assembly according to any of claims 1 to 9 wherein an insulator (40a, 40b) of the at least one ribbon cable (120) is formed from expanded polytetrafluoroethylene.
12. Electrical signal cable assembly according to any of claims 1 to 9 wherein an insulator (40a, 40b) of the at least one ribbon cable (120) is formed from full density polytetrafluoroethylene.
- 25

#### Patentansprüche

- 30 1. Stromsignalkabelbaugruppe, die folgendes umfaßt (110) :
  - mindestens ein Flachkabel (120), das in mindestens einem ersten konzentrischen Array um einen zylindrischen Abstandshalter herum angeordnet ist,
  - einen trennenden konzentrischen Abschirmungsstreifen (150), der um das erste konzentrische Array (120) herum angeordnet ist, und
  - 35 - mindestens ein weiteres Flachkabel (120), das in mindestens einem weiteren konzentrischen Array um den trennenden konzentrischen Abschirmungsstreifen (150) herum angeordnet ist.
2. Stromsignalkabelbaugruppe (110) nach Anspruch 1, wobei das mindestens eine Flachkabel (120) mehrere elektrische Leiter (130) umfaßt und
- 40
  - mindestens einer der mehreren elektrischen Leiter (30) an Wechselstrommassepotential angeschlossen werden kann und
  - mindestens ein weiterer der mehreren elektrischen Leiter (30) an ein Signal angeschlossen werden kann.
- 45 3. Stromsignalkabelbaugruppe (110) nach einem der vorhergehenden Ansprüche, wobei die Flachkabel (120) um den zylindrischen Abstandshalter (190) herumgelegt werden.
4. Stromsignalkabelbaugruppe (110) nach einem der vorhergehenden Ansprüche, wobei eine Außenabschirmung (170) um das weitere konzentrische Array (120) herum angeordnet ist.
- 50 5. Stromsignalkabelbaugruppe (110) nach Anspruch 4, wobei ein äußeres Bindemittel (165) zwischen dem weiteren konzentrischen Array (120) und der Außenabschirmung (170) angeordnet ist.
- 55 6. Stromsignalkabelbaugruppe (110) nach einem der vorhergehenden Ansprüche, wobei ein Mantel (180) um eine Außenseite der Stromsignalkabelbaugruppe (110) herum angeordnet ist.
7. Stromsignalkabelbaugruppe (110) nach einem der obigen Ansprüche, weiterhin mit mindestens einem Flachkabel

(120), das in mindestens einem dritten konzentrischen Array (120) um das weitere konzentrische Array (120) herum angeordnet und durch einen weiteren konzentrischen trennenden Abschirmungsstreifen (150) von dem weiteren konzentrischen Array (120) getrennt ist.

- 5 8. Stromsignalkabelbaugruppe (110) nach einem der vorhergehenden Ansprüche, wobei das mindestens eine Flachkabel (120) einen oberen Isolator (40a) umfaßt, der an einem unteren Isolator (40b) befestigt ist, wobei mehrere elektrische Leiter (130) darin angeordnet sind.
9. Stromsignalkabelbaugruppe nach Anspruch 8, wobei  
10 der Flachkabelisolator (40a, 40b) einen an einen unteren Isolator (40b) gesinterten oberen Isolator (40a) umfaßt.
10. Stromsignalkabelbaugruppe nach einem der vorhergehenden Ansprüche, wobei der Isolator (40a, 40b) des mindestens einen Flachkabels (120) ausgebildet ist aus der Gruppe aus Isoliermaterialien bestehend aus Perfluoralkoxy, Fluorethylenpropylen, Polyester, Polyolefin einschließlich Polyethylen und Polypropylen, Polymethylpenten,  
15 volländigem Polytetrafluorethylen oder gerecktem Polytetrafluorethylen.
11. Stromsignalkabelbaugruppe nach einem der Ansprüche 1 bis 9, wobei  
ein Isolator (40a, 40b) des mindestens einen Flachkabels (120) aus gerecktem Polytetrafluorethylen ausgebildet  
20 ist.
12. Stromsignalkabelbaugruppe nach einem der Ansprüche 1 bis 9, wobei  
ein Isolator (40a, 40b) des mindestens einen Flachkabels (120) aus volländigem Polytetrafluorethylen ausgebildet  
ist.

## Revendications

1. Assemblage de câble pour signaux électriques (110), comprenant  
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  - au moins un câble-ruban (120) agencé suivant une première configuration concentrique autour d'un espaceur cylindrique,
  - une bande de blindage concentrique de séparation (150) disposée autour de la première configuration concentrique (120), et
  - au moins un câble-ruban supplémentaire (120) agencé suivant au moins une configuration concentrique supplémentaire autour d'une bande de blindage concentrique de séparation (150).
2. Assemblage de câble pour signaux électriques (110) selon la revendication 1, dans lequel ledit au moins un câble-ruban (120) comprend une pluralité de conducteurs électriques (130) et  
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  - au moins un parmi la pluralité de conducteurs électriques (30) est susceptible d'être connecté au potentiel de la masse CA, et
  - au moins un conducteur supplémentaire parmi la pluralité de conducteurs électriques (30) est susceptible d'être connecté à un signal.
- 45 3. Assemblage de câble pour signaux électriques (110) selon l'une quelconque des revendications précédentes, dans lequel lesdits câbles-rubans (120) sont répartis autour de l'espaceur cylindrique (190).
4. Assemblage de câble pour signaux électriques (110) selon l'une quelconque des revendications précédentes, dans lequel un blindage extérieur (170) est disposé autour de la configuration concentrique supplémentaire (120).  
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5. Assemblage de câble pour signaux électriques (110) selon la revendication 4, dans lequel un liant extérieur (165) est disposé entre la configuration concentrique supplémentaire (120) et le blindage extérieur (170).
6. Assemblage de câble pour signaux électriques (110) selon l'une quelconque des revendications précédentes, dans lequel une gaine (180) est disposée autour de l'extérieur dudit assemblage de câble pour signaux électriques (110).  
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7. Assemblage de câble pour signaux électriques (110) selon l'une quelconque des revendications précédentes,

comportant en outre au moins un câble-ruban (120) disposé suivant au moins une troisième configuration concentrique (120) autour de la configuration concentrique supplémentaire (120) et séparé de la configuration concentrique supplémentaire (120) par une bande de blindage concentrique de séparation supplémentaire (150).

- 5 8. Assemblage de câble pour signaux électriques (110) selon l'une quelconque des revendications précédentes, dans lequel ledit au moins un câble-ruban (120) comprend un isolant supérieur (40a) fixé à un isolant inférieur (40b), avec une pluralité de conducteurs électriques (130) disposés à l'intérieur.
- 10 9. Assemblage de câble pour signaux électriques selon la revendication 8, dans lequel ledit isolant (40a, 40b) de câble-ruban comprend un isolant supérieur (40a) aggloméré par frittage sur un isolant inférieur (40b).
- 15 10. Assemblage de câble pour signaux électriques selon l'une quelconque des revendications précédentes, dans lequel l'isolant (40a, 40b) dudit au moins un câble-ruban (120) est formé à partir du groupe de matériaux isolants constitué d'un perfluoroalcoxy, d'un fluoroéthylène-propylène, d'un polyester, d'une polyoléfine, notamment le polyéthylène et le polypropylène, le polyméthylpentène, le polytétrafluoroéthylène pleine densité ou le polytétrafluoroéthylène expansé.
- 20 11. Assemblage de câble pour signaux électriques selon l'une quelconque des revendications 1 à 9, dans lequel un isolant (40a, 40b) dudit au moins un câble-ruban (120) est formé de polytétrafluoroéthylène expansé.
- 25 12. Assemblage de câble pour signaux électriques selon l'une quelconque des revendications 1 à 9, dans lequel un isolant (40a, 40b) dudit au moins un câble-ruban (120) est formé de polytétrafluoroéthylène pleine densité.
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